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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

REQUEST FORM FOR FILING CONTINUING APPLICATION UNDER 37 C.F.R. § 1.53(b)

Attorney Docket Number: 47382.000112
Anticipated Classification Of This Application:
Class _________ Subclass _____________

Prior Application: 09/520,166 (47382.000102)
Examiner: Unassigned
Art Unit: 3747

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

This is a request for filing a **[X]** continuation [ ] divisional application under 37 C.F.R. § 1.53(b) of prior Application Serial No. **09/520,166**, filed on **March 7, 2000** which is a continuation of prior Application Serial No. **09/398,199**, filed on **September 17, 1999**, which claims priority to provisional application Serial No. **60/100,913**, filed on **September 17, 1998**, which is entitled **REMOTE EMISSIONS SENSING SYSTEM WITH IMPROVED NO_x DETECTION** by the following named inventors: **John DIDOMENICO and Craig S. RENDAHL**

1. **[X]** Enclosed is a true copy of the prior complete application as originally filed.
2. [ ] Preliminary Amendment is enclosed.
3. [ ] Cancel in this application original claims _________ of the prior application before calculating the filing fee. At least one original independent claim is retained complete the prior application introduced new matter therein.
4. **[X]** The filing fee is calculated on the basis of the claims existing in the prior application as mentioned at 1, 2 and 3 above.

FOR	NUMBER FILED	NUMBER EXTRA	RATE	CALCULATIONS
TOTAL CLAIMS	17	0	x $ 18.00 =	$ 0.00
INDEPENDENT CLAIMS	2	0	x $ 78.00 =	$ 0.00
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			x $	$ 0.00
			BASIC FEE	+ $ 710.00
			TOTAL OF ABOVE CALCULATIONS=	+ $ 710.00
REDUCTION BY ½ FOR FILING BY SMALL ENTITY (Note 37 C.F.R 1.9, 1.27, 1.28) IF APPLICABLE, VERIFIED STATEMENT MUST BE ATTACHED.				- $ 0.00
			TOTAL =	$ 710.00

5. **[X]** The Commissioner is hereby authorized to charge $2,100.00 (of which $710.00 is to cover the fee for filing this continuation) and ($1,390.00 is for the four-month extension fee) under 37 C.F.R. § 1.16 and § 1.17 which is required to Deposit Account No. 50-0206. In the event any variance exists between the amount and the Patent Office charges, please credit or charge any different to Deposit Account No. 50-0206.
6. [ ] A check in the amount of $_____ In the event any variance exists between the amount enclosed and the Patent Office charges, please credit or charge any different to Deposit Account No. 50-0206.

7. **[X]** Amend the specification by inserting before the first line the sentence:
This application is a continuation of Application Serial No. **09/520,166**, filed **March 7, 2000**,
This application is a continuation of Application Serial No. **09/398,199**, filed **September 17, 1999**, which claims priority to Provisional Application Serial No. **60/100,913** filed **September 17, 1998**.

8. [ ] A verified statement to establish small entity status under 37 C.F.R. §§ 1.9 and 1.27
   [ ] is enclosed.
   [ ] was filed in prior application Serial No. ______ and such status is still proper and desired (37 C.F.R. § 1.28(a)).

9. [ ] Priority of foreign Application Nos. ________, filed on _______, is claimed under 35 U.S.C. § 119.
   [ ] A certified copy of each was filed in prior Application Serial No. _____, filed ____.

10. [ ] New formal drawings are enclosed.

11. [ ] The prior application is assigned of record to ________________________.

12. [ ] The power of attorney in the prior application is to Hunton & Williams.
   a. [ ] The power of attorney appears in the original papers in the prior application.
   b. [ ] Since the power does not appear in the original papers, a copy of the power in the prior application is enclosed.
   c. [ ] Recognize as Associate Attorneys:
   d. [ ] Please remove as power of attorney:

13. **[X]** Also enclosed: An INFORMATION DISCLOSURE STATEMENT. Attached are Forms PTO-1449 listing all of the documents cited by Applicants and the PTO in the parent application(s) relied upon 35 U.S.C. 120. Per Rule 98(d) copies of those documents are not required now. Please consider these documents and advise that they have been considered in this new application by returning a copy of the enclosed Forms PTO-1449 with the Examiner's initials in the left column per M.P.E.P. 609.

14. **[X]** Address all future communications to:

James G. Gatto, Esq.
Hunton & Williams
1900 K Street, N.W.
Washington, D.C. 20006-1109

The undersigned further declares that all statements made herein of his own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that willful false statements may jeopardize the validity of the applications or any patent issuing thereon.

Dated: November 13, 2000

By: ______________________
Devin S. Morgan
Registration No. 45,562

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REMOTE EMISSIONS SENSING SYSTEM WITH IMPROVED NO_x DETECTION

Field of the Invention

Remote emissions sensing system and method with improved nitrous oxide (NO_x) detection, including processing to account for the presence of ambient NOx.

Background of the Invention

Remote emissions sensing systems generally are known. One such system comprises a source of electromagnetic radiation arranged to pass a beam of radiation through the exhaust plume of a motor vehicle as the motor vehicle passes by the system, and one or more detectors arranged to receive the radiation after it passes through the exhaust plume of the vehicle. A filter may be associated with one or more detectors to enable the detector to determine the intensity of electromagnetic radiation having a particular wavelength or range of wavelengths. The wavelengths may be conveniently selected to correspond to wavelengths absorbed by molecular species of interest in an exhaust plume (e.g., HC, CO, CO2, NO_x, or other molecular species). The one or more detector output voltages that represent the intensity of the electromagnetic (em) radiation measured by that detector. The voltages are input to a processor. The processor calculates the difference between the known intensity of the light source and the intensity detected by the detectors to determine the amount of absorption by particular molecular species (based on predetermined wavelengths associated with that species). Based on the measured absorption(s), the concentration of one or more molecular species in the emissions may be

determined in a known manner. For various reasons, inaccuracies can occur when remotely sensing emissions.

Some remote emission sensing systems do not have the capability to detect NO_x. Other systems detect NO_x, but suffer from various drawbacks. One problem is that when detecting the NO_x concentration present in an exhaust plume, the presence of ambient NO_x can adversely affect the accuracy of the detected concentration. For example, if two cars pass a test station within a relatively short time period, NO_x emissions from the first car may linger and be mixed with the exhaust plume of the second car thereby skewing the measurement of NO_x concentration of the second car. Other sources of ambient NO_x may lead to a similar result.

A second problem arises due to variations in light source intensity. Generally, to detect the NO_x concentration in an exhaust plume, the output of a detector adapted to determine the amount of absorption of the light beam due to the presence of NO_x is compared to a value indicative of the intensity of the light source, with the difference representing the amount of absorption due to the presence of NO_x.

Typically, a standard value is used for the light source intensity. However, variations in the actual intensity of the source can cause inaccuracies in the detected amount of NO_x. A third problem arises due to the presence of noise. Other problems and drawbacks exist.

<u>Summary of the Invention</u>

One object of the invention is to overcome these and other limitations, problems and drawbacks of prior systems and methods.

Another object of the present invention is to increase the reliability and accuracy of NO_x

readings taken in a remote emissions sensing system.

Another object of the invention is to improve the accuracy of NO_x emissions readings by accounting for the presence of ambient NO_x.

Another object of the invention is to improve the accuracy of NO_x emissions readings by accounting for the presence of ambient noise.

It is another object of the invention to improve the processing efficiency of NO_x concentration calculations.

These and other objects of the invention are accomplished according to various embodiments of the present invention. According to one embodiment of the present invention a remote emissions sensing system is provided with NO_x detection capability. Ideally, the NO_x detected is the NO_x present in the exhaust plume emanating from a motor vehicle being tested. To account for ambient NO_x (for example, from a previous car), for each vehicle whose exhaust is measured, an ambient NO_x concentration reading is taken. Preferably, a "blocked" beam reading is also taken prior to exhaust plume measurement. The ambient and blocked beam readings are both subtracted from the exhaust plume reading to render a more accurate exhaust concentration reading.

Additionally, the system may be configured to process exhaust plume readings only in a predetermined wavelength band associated with the known absorption spectrum of NO_x.

The above and other objects, features and advantages of the present invention will be better understood from the following detailed description of the invention.

Brief Description of the Drawings

Figure 1 depicts a schematic representation of intensity versus wavelength data for one embodiment of the invention.

Figure 2 depicts a schematic representation of intensity versus wavelength data for another one embodiment of the invention.

Detailed Description of the Invention

According to one embodiment, the emissions detection may be performed by a remote sensing device, such as RSD-1000 or RSD-2000, manufactured by RSTi, Tucson, Arizona.

Typically, the remote sensing device and analyzer system includes at least one source of radiation (*e.g.*, infrared (IR), ultra-violet (UV), etc.), at least one detector of radiation, and a processor to process the detected radiation signals. According to one embodiment of the invention, the radiation emitted by the source(s) may be directed across a roadway along a predetermined path. In some embodiments, additional optics or beam directing devices may be used to re-direct the beam of radiation. Ultimately, the source radiation is received by the detector(s). Other system configurations may also be used. When a vehicle passes along roadway, the source beam(s) may pass through an exhaust plume of the vehicle.

The detector(s) record the presence of various exhaust constituents (*e.g.*, HC, CO_2, CO, NO_x, etc.), typically, by recording a voltage level indicative of the amount of absorption of the source beam. The processor, in part, performs an analysis of the plume to analyze the exhaust emissions in a known manner.

According to one embodiment of the present invention, the remote emission detector (RSD) system takes a reading of the ambient NO_x concentration present just prior to each vehicle passing through the system. As the vehicle is passing through the system, the RSD system takes

a "blocked" reading (*i.e.*, a reading when the vehicle is located in the path of the beam between the source and detector). This reading may reflect any ambient or system noise which may be present. The RSD system also takes a reading of the exhaust plume as the beam passes through the plume. Thus, in accordance with a one embodiment of the present invention, for each vehicle whose NO_x reading is to be taken, at least three measurements are made, including an ambient concentration reading, a "blocked" reading and an exhaust plume reading. Since the ambient concentration and noise can vary from test to test, detecting the ambient NO_x concentration and noise for each test can permit more accurate and reliable NO_x concentration determinations to be made.

Each of the readings is made by one or more detectors. The outputs of the detector(s), reflecting the ambient NO_x reading, the blocked beam reading and the exhaust plume reading (and other desired data), are provided to a processor. The processor determines the ambient concentration of NO_x and the concentration of NO_x from the exhaust plume and subtracts the ambient concentration from the NO_x concentration from the plume for each vehicle tested. Preferably, the blocked beam reading for each vehicle is subtracted from the exhaust plume reading for that vehicle to remove ambient and or system noise to further improve the accuracy and or reliability of the test results.

Each of the readings and the process and system for obtaining reliable NO_x readings in connection with a remote sensing system will now be discussed in more detail. Initially, as the vehicle approaches the light beam, the baseline ambient concentration reading is taken. In connection with this step the detector measures the ambient NO_x concentration just prior to the vehicle's entry into and through the light beam. The baseline ambient concentration readings

may be scheduled to occur periodically when no vehicle or emissions source is within detection range. Thus, the most recent reading for ambient concentration may be stored and used in connection with the concentration calculation for each vehicle. Alternatively, a trigger event may cause the RSD system to take the ambient concentration reading. In either case, the readings are preferably obtained by taking a plurality of samples at short intervals over a predetermined measurement interval. For example, an ambient reading may comprise 50 samples at 10 ms. intervals over a 0.5 second measurement interval.

Once a vehicle breaks the light beam, a "blocked" reading or "dark current" reading, may be performed. This reading measures baseline current and noise in the system. The baseline values may change during the course of the day as it is dependent upon, for example, ambient temperature. The "blocked" reading is taken for each vehicle for which an NO_x reading is desired. Preferably, the blocked reading is taken after the ambient concentration reading but prior to the exhaust plume reading. The exhaust plume reading is taken based upon the actual emissions from each vehicle to be measured, in a known manner.

One embodiment of the present invention incorporates certain data processing routines conveniently chosen to increase the accuracy and validity of resulting NO_x concentrations. Figure 1 depicts a typical data plot that may result from an absorption measurement of NO_x. The Y axis contains radiation intensity values and the X axis contains radiation wavelength values. An absorption of radiation will typically appear as a dip in the signal at particular wavelengths. For example, absorption of NO will typically occur centered substantially around wavelengths of 326 nm. In a known manner, exhaust emission data is typically normalized or ratioed by comparison with another exhaust constituent (*e.g.*, CO_2). Certain existing systems may ratio

using data corresponding to a range of wavelengths indicated by bracket A on Fig. 1. As can be seen, this range includes many data points for which there is no significant absorption of NO_x. Thus, any noise or other inaccuracies present in these non-absorptive wavelengths may lead to erroneous results in determining the concentration of NO_x in the exhaust emissions. The present invention reduces errors of this sort by selecting a convenient range of wavelengths over which to ratio. For example, as shown in Fig. 1, a range of wavelengths, indicated by bracket B and substantially centered around an absorption dip may be used to calculate a ratio.

The present invention also compensates for changes in the intensity of the radiation to calculate a more accurate NO_x concentration. Fig. 2 depicts two absorption signals (indicated as "a" and "b" in Fig. 2) for two measurements of NO_x concentration. The apparent shift in the curves may be caused by a variety of reasons. For example, as ambient conditions (*e.g.*, air temperature, humidity, etc.) change, the intensity may also change and cause a shift in the detected signal. The present invention compensates for such an effect by subtracting a baseline intensity from each signal. The baseline intensity may be calculated by a variety of methods. For example, a substantially linear region (indicated as "c" and "d" on Fig. 2) may be used to obtain a baseline intensity level. Thus, each measurement will preferably have a baseline corresponding to the identical conditions during which the measurement was taken and a more accurate determination of NO_x concentration may be calculated.

Other embodiments and uses of the invention will be apparent to those skilled in the art from consideration of the specification and practice of the invention disclosed herein. The specification and examples should be considered exemplary only.

I claim:

1. A method for remote emissions sensing with NO_x detection capability comprising the steps of:

taking an ambient reading of ambient NO_x concentration present prior to a vehicle passing by a system for remote emissions sensing;

taking an exhaust plume reading of an exhaust plume of the vehicle as the vehicle passes by the system for remote emissions sensing; and

subtracting the ambient NO_x concentration reading from the exhaust plume reading to provide a concentration reading for the NO_x present in the vehicle emissions.

2. The method of claim 1 further comprising the steps of taking a blocked beam reading prior to taking an exhaust plume reading and when the vehicle is in the path of a source beam of the system; and

subtracting the blocked beam reading from the exhaust plume reading.

3. The method of claim 2, wherein the ambient reading is taken at predetermined intervals and wherein the most recent reading is stored and used in connection with the blocked beam and exhaust plume readings for each vehicle.

4. The method of claim 1, wherein the ambient reading is taken at an occurrence of a predetermined trigger event.

5. The method of claim 2, wherein the blocked beam reading measures baseline current or noise in the system and wherein the blocked beam reading is taken after the ambient reading but before the exhaust plume reading.

6. The method of claim 1, wherein a range of wavelengths substantially centered around a characteristic wavelength is selected over which to take readings so that the number of data points for which there is no significant NO_x absorption is minimized.

7. The method of claim 1, further comprising the step of subtracting a baseline intensity from each exhaust plume reading to compensate for changes in radiation intensity.

8. The method of claim 6, wherein the baseline intensity is calculated using a substantially linear region over an absorption dip.

9. The method of claim 2, wherein the ambient reading is taken just prior to the blocked beam reading.

10. A system for remote emissions sensing with NO_x detection capability comprising:

a source beam of radiation;

a means for taking an ambient reading of ambient NO_x concentration present prior to a vehicle passing by the system;

a means for taking an exhaust plume reading of an exhaust plume of a vehicle; and

a means for subtracting the ambient NO_x concentration reading from the exhaust plume reading.

11. A system as claimed in claim 10 further comprising a means for taking a blocked beam reading when the vehicle is in the path of the source beam; and

a means for subtracting the blocked beam reading from the exhaust plume reading.

12. The system of claim 10, wherein the ambient reading is taken periodically at predetermined intervals and the most recent reading is stored and used in connection with the exhaust plume reading for each vehicle.

13. The system of claim 10, wherein the ambient reading is taken at the occurrence of a predetermined trigger event.

14. The system of claim 11, wherein the blocked beam reading measures baseline current or noise in the system, and where the blocked beam reading is taken after the ambient reading but before the exhaust plume reading.

15. The system of claim 10, wherein a range of wavelengths substantially centered around a characteristic wavelength is selected over which to take readings so that the number of data points for which there is no significant NO_x absorption is minimized.

16. The system of claim 10, wherein changes in the intensity of the source radiation are compensated by subtracting a baseline radiation intensity from each exhaust plume reading.

17. The system of claim 16, wherein the baseline intensity is calculated using a substantially linear region over an absorption dip.

Abstract

A remote emissions sensing system is provided with NO_x detection capability. First, a reading of the ambient NO_x concentration is taken just prior to each vehicle passing through the system. This measurement accounts for any ambient NO_x concentration that may be lingering from the exhaust of a previous vehicle. Next, the system takes a blocked reading when the vehicle is located in the path of the beam. This reading accounts for any ambient or system noise that may exist. Finally, the system takes a reading of the exhaust plume as the beam passes through the plume. A processor determines the portion of the reading due to the exhaust plume by subtracting the ambient and blocked readings from the exhaust plume reading. As a result, a more accurate exhaust concentration reading is provided. Additionally, the system may process exhaust plume readings only in a predetermined wavelength band associated with the known absorption spectrum of NO_x so that data points for which there is no significant absorption of NO_x may be eliminated. Thus, any noise or other interference in the non-absorptive wavelengths are minimized. Also, changes in the intensity of the radiation are compensated by subtracting a baseline intensity from each signal.

NOx

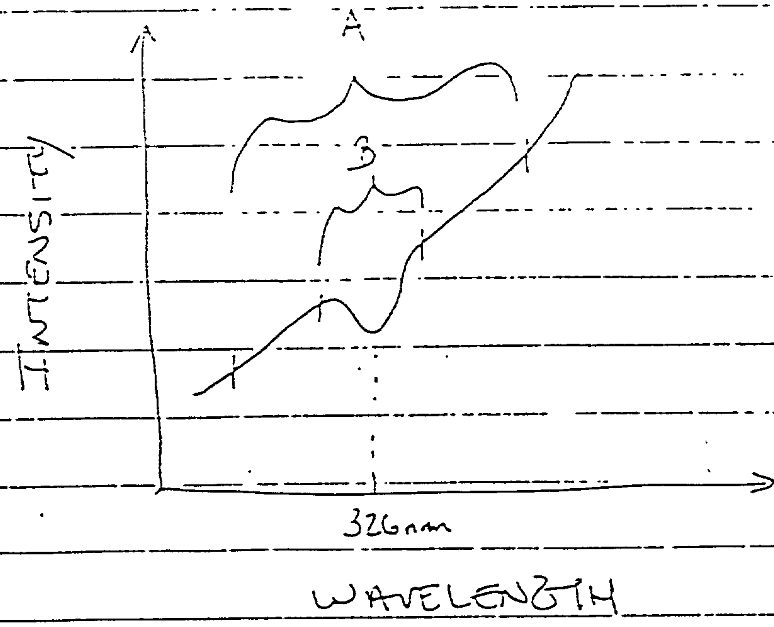

FIG. 1

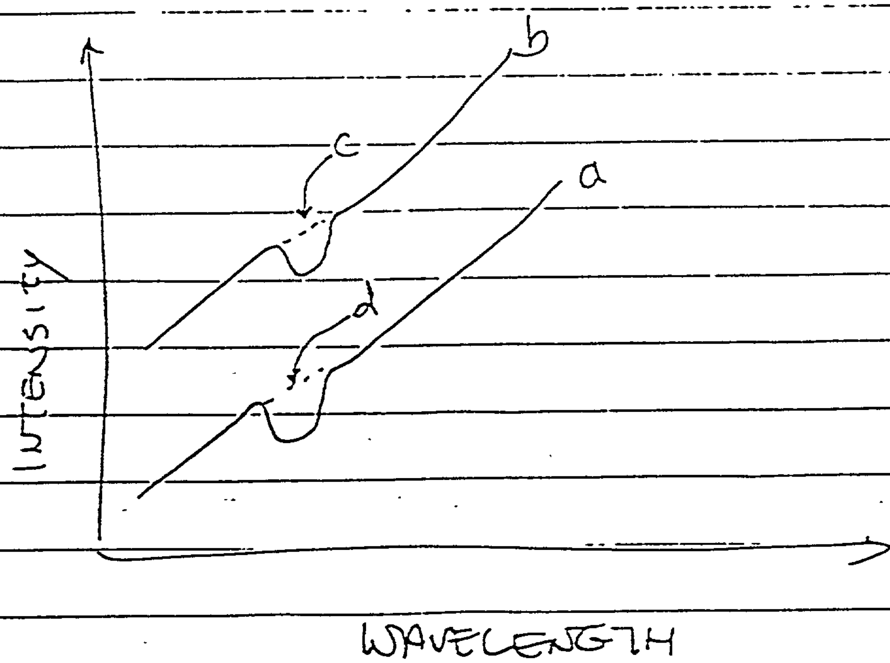

FIG 2.